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PRINCIPLES OF CREATION UNIFIED BASE COMPLEX OF NAVIGATION AND LANDING EQUIPMENT

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Abstract. *Based on apparatus-analogue characteristics analysis, requirements of international technical documents, with regard of operational, economic and technical conjuncture principles and construction ways of base complex of navigation-landing equipment for "small aviation" and possibilities of its technical realization are shown. The different variants of the unified units depending on the destination are known. The brief comparative analysis is made.*

Keywords: onboard navigation and landing equipment; unified block; quality indicators.

Currently serially produced domestic onboard equipment of navigation VOR-85 and landing ILS-85, which was established in accordance with international recommendations ARINC-710, ARINC-711 and requirements airworthiness – RA-3. Indicated navigation-landing equipment is intended for use in onboard aircraft complexes navigation equipment, which equipped on "large" and "medium" aircrafts generation IV. At the same time, "small aviation" – airplanes local airlines and general aviation, which can not to place onboard navigation instruments with sufficiently overall dimensions and weight and practically can not use information fields of systems ILS, VOR.

Introduction

The purpose of this paper is to explore and justification of the most rationally in a technical and economical variant unified set of on-board complex navigation and landing equipment (CNLE) for perspective planes, including for unmanned aerial vehicles, which are based on the stationary airfields and platforms, working in the field of information-power beacons, instrument landing system (ILS) and very high frequency omnidirectional radio range (VOR), and marker beacon (MRM). It is thus necessary maximally to use experience of development, making, tests, initial stages of exploitation, dynamic modernization of apparatus of ILS-85 and VOR-85, periodically arising up in connection with the brushing up requirements of international standards to flight safety of aircrafts.

The most acceptable method of determination of technical and economic indexes on the initial stages of designing is a comparable method, based on comparing of possible variants of apparatus to the present analogues. To such analogues it is possible to take the apparatus of ILS-85, VOR-85 (combined with a marker radio receiver – MRR), which was taken into account when developing modern condition and trends of work in this direction in leading international companies. At that should be made decisions, which take into consideration technical and economic parameters as well as possibility of its implementation.

Technical and economic indices of efficiency design of on-board radio electronic equipment

Technical and economic efficiency of experimental design of on-board radio electronic equipment consists of indicators:

– the quality of the developed product, its reliability and longevity;

– technological and structural continuity;

– operational and repair manufacturability of construction;

– the level of costs to maintain the equipment in working during the effective functioning.

The specified indicators for unified CNLE are represented as follows.

Quality indicators. High characteristics of accuracy, noise immunity, selectivity, i. e. quantitative indicators of quality, that meet the requirements of international standards, allow us to create effective highly reliable equipment operating in the most difficult conditions.

The level of reliability of self-control equipment ensures operation of the equipment that does not require traditional methods of verifying its performance, i. e. pass to a new quality of service – service of the equipment "on condition".

The expected increase in the quality of the equipment should be achieved through a more modern material base of production, rigging production plant with new equipment and the introduction of advanced production processes.

A distinctive feature of unified apparatus CNLE is also indicators of the quality of the rational redistribution of the management and processing of signals between the hardware and the mathematical software tools using a microprocessor, which, in general, has led to a significant reduction of hardware products relative analogue.

Indicators of technological and structural succession. If quality indicators mainly determine the technical efficiency of the developed equipment, the

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cost-efficiency, besides performance, determines the technical and structural performance and, above all, the level of unification. Increase the level of unification in the equipment CNLE is achieved through the development of its standards-based constructive, i. e., the use of standardized and unified assembly units in various possible hardware trim levels.

High technological characteristics of the equipment are provided by the use of the modular method of design which increases maintainability, interchangeability, the possibility of followed modernization and basic extension of equipment.

One important fact is that the equipment and products NLE ILS-85, VOR-85 serially are mastering on the single enterprise, which means the implementation of technological and structural succession different generations of equipment. This leads to a relatively high rate of development of unified NLE in production.

Typification technology on the serial enterprise reduces the number of technological processes and decrease of development costs.

Indicators of operational and repair of technological design. To provide high operational performance, required characteristics of maintainability, the ability of upgrade and building capacity the developing of NLE should include the following steps of selecting methods and techniques of design:

– the principle of group design – allows us to create a group of modifications of on-board equipment for use on aircraft of various classes;

– the principle of aggregation – allows the rational division of pieces of equipment to the components for the implementation of ideas of a modular set of various sets equipment. This provides the rational methods of production, maintenance, equipment repair and repeated use of its components in the development of different variants of the equipment;

– the basic principle of unification – allows the development based on a basic kit consisting of a complete set of developed blocks;

– the principle of interchangeability – provides the use of equipment in CNLE modules ILS-85, VOR-85.

*Indicators of cost of maintaining equipment in working condition.*The cost of operating the equipment are mainly made up of the cost of preventive procedural works on the maintenance and repair of equipment, and these costs are inversely proportional to the mean time between failures. The sharp reduction in operating costs should happen due to the development of several variants of unified equipment for various purposes.

Cost reduction is also expected due to a single approach to operational maintenance and repair of equipment products CNLE ILS-85, VOR-85 when used for the control of a single calibration and measurement technique [2] in the aviation technical bureau and repair facilities.

Analysis of the possibility of the requirements of international technical documents to navigation and landing equipment. It is advisable to analyze the possibility of providing a developed equipment requirements CNLE RA-3, because, in this document takes into account the most stringent specifications on-board aviation radio equipment.

a) Course channel receivers ILS, SP-50, VOR.

*The requirements for sensitivity, noise immunity, electromagnetic compatibility (EMC).*To provide the sensitivity of better than 3 mcV for amplitude-modulated signals in view margin of technological design requires sensitivity less than 1 mcV. As tests of high-frequency paths products ILS-85, VOR-85 show, so the receiver sensitivity of the course really is attainable, while in the mode of the SP-50 receiver will have more than 3 times better sensitivity than required.

To satisfy requirements of noise immunity suppression of the noise with frequency that is separated from the working channel by ± 40 kHz, should be not less than 60 dB, and separated by ± 90 kHz – not less than 80 dB.

In this work equipment is provided as the receiver ILS III categories, in accordance with the recommendations ARINC-710, and in the mode VOR, according to ARINC-711.

The selectivity mentioned above can be ensured if we will use 2 cascades of quartz filters in the intermediate frequency amplifier channel of the receiver, and its thorough design elaboration [2].

Implementation of requirements for the protection of the cross intermodulation noise, and other requirements of the EMC provided with a choice of structure and circuit solutions of entrance cascades of receiver [3].

*Requirements for the accuracy characteristics.*To provide accuracy of product performance:

– errors in centering mode ILS no more than 0.0077 DDM in the mode SP-50 is not more than ± 1,16 % CAM with 99,7 % probability (where the DDM and the CWA – the parameters of precision of equipment landing characteristics [4]);

– error in determining the azimuth in the mode VOR no more than ± 0,5 deg probability of 0,95;

– linearity deviation in ILS mode is not more than 10 %, it is necessary to determine the extent of permissible amplitude and phase distortion in the high frequency tract, low frequency tract, the degree of suppression of interfering low-frequency (LF) and high frequency (HF) signals, the bit of data in the channel digital baseband processing.

The results of the analysis and calculations show that the required precision characteristics are provided with a sufficient margin technology.

Thus, minimizing the amount of analog devices and the use of digital signal processing ensures high accuracy characteristics of independence from the influence of destabilizing factors.

b) Glide path channel receivers ILS, SP-50.

The requirements for sensitivity, noise immunity and EMC. For providing of sensitiveness not worse 6 mcV, taking into account a technological stock, a calculation sensitiveness is needed no more than 2 mcV. Such sensitiveness is really attainable and at using as a prototype of the technical solutions accepted in the apparatus of ILS-85.

Requirements for the accuracy characteristics. For providing of error of centering ± 0,014 and linearity of rejection ± 10 % it is necessary to define the degree of possible distortions of glide signal HF and LF tracks, suppression of interfering signals, bit of arrays of data in the channel of digital treatment of LF signals.

The results of analyses and calculations show that the required descriptions of accuracy are provided with a sufficient technological margin.

The use of digital LF signals processing provides with sufficient independence of accuracy characteristics of glide channel from the effects of destabilizing factors.

c) The marker channel.

Relatively low sensitivity to the requirements of the marker receiver allows it to provide optimal construction of the EMC requirements. The results of the analysis and calculation show reality, that all requirements RA-3 marker to the receiver.

d) Energy consumption.

The use of radio equipment and digital circuits with low power consumption, as well as the secondary power supply module with single-ended converter and a high coefficient of performance (COP) allows the consumption of the onboard power supply no more than 30 VA facilities.

Specifications and design of complex navigation and landing equipment built on the above principles, are developed and produced at Kiev enterprise "Radioizmeritel", single complex one of variants CNLE is shown in Figs 1 and 2.

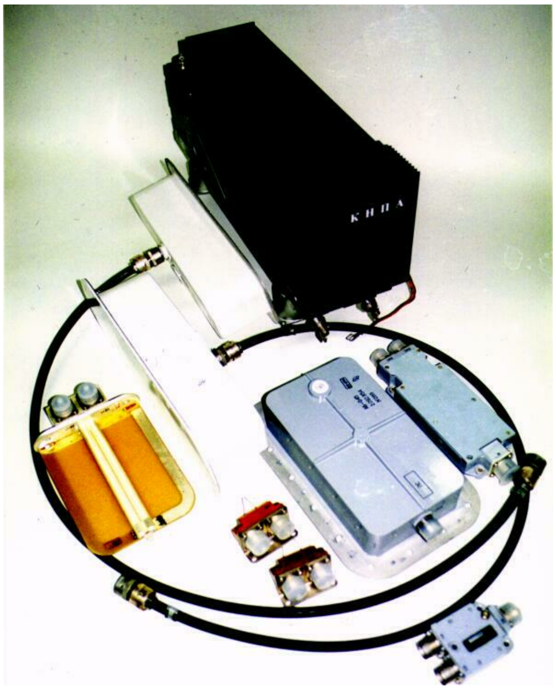

Fig. 1. Unified complex navigation and landing equipment –CNLE in complete set with antenna-feeder devices: navigation, landing-course and glide path, the marker

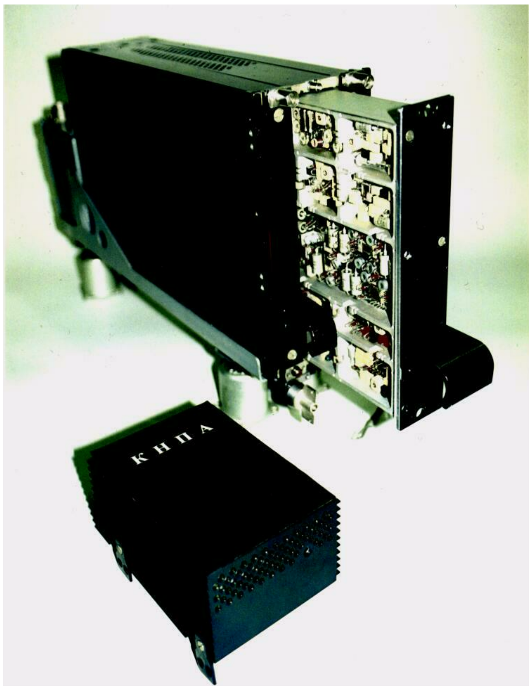

Fig. 2. Construction of block of NLE and constituent modules

Integration of unified modules of aircraft onboard navigation and landing equipment

In accordance with international recommendations ARINC-710, ARINC-711, the series-produced domestic apparatus of instrument landing system ILS-85 and navigations of very high frequency omnidirectional radio range VOR-85 is executed in separate block constructive [1], [3]–[9].

Principles and production technology of the above-mentioned products are well established. It is advisable to consider the possibility of using them in one compact product for the aggregation of navigation and landing functions, intended for “small aviation” of various purposes.

Taking as a base structure products ILS-85 and VOR-85, will define which elements of these products can be combined for build of integration variant NLE.

The apparatus ILS-85 may be split on following functional-structural devices: receiver HF signals course; receiver HF signals glide, device of digital communication and management, analog-digital processing (signal course and glide path), telephone channel, secondary power source.

Similarly, the apparatus VOR-85 can be divided into the following functional-structural devices: receiver HF signals navigation; receiver HF marker, device of digital communication and management, analog-digital processing (navigation), telephone channel navigation, telephone channel marker, secondary power source.

Analysis of the functions performed by a combined hardware shows that there are a number of devices, which after certain modifications may be used in both the mode of landing and navigations.

Receiver of high-frequency navigation and course signals is one of such devices, if the tuning for both digital set of navigation frequencies and fixed landing frequencies can be provided.

Development of the next unified devices is possible: analog-to-digital processing unit (the signals course, glide and/or navigation channels), digital communication unit and control of the secondary power supply unit.

Unified block of navigation and landing equipment (NLE)

Based on the above, taking into account the structural, circuit engineering and design development unit NLE composition of constructive models (CM1 .... CM4), their modes of operation, dimensions and weights are given in the Table. CM1... CM4 structurally are finished products.

Block diagram of the unified block NLE is shown in Fig. 3.

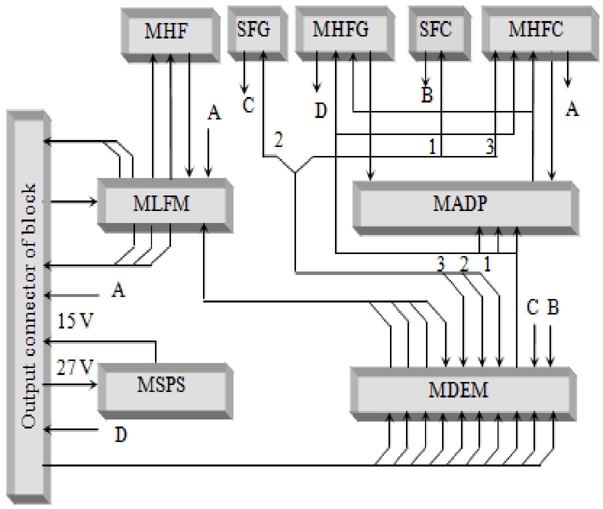

Fig. 3. Block diagram of the unified block NLE

Thus, functionally and constructively, a unified block NLE consists of four standard removable CM with total width of panel is equal 90 mm.

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Composition of constructive models, their modes of operation, dimensions and weights

Code CM	Name of component part (code)	Modes of operation		Overall dimensions, mm	Weight, kg
		Navigation	Landing		
CM1	1. Module of high-frequency course(MHFC)	+	+	22,5×192×293	0,7
	2. Synthesizer of the frequency course (SFC)	+	+		
CM2	1. Moduleof high-frequency glide(MHFG)	-	+	22,5×192×293	0,7
	2. Synthesizer of the frequency glide (SFG)	-	+		
CM3	1. Module of a digital exchange and management (MDEM)	+	+	22,5×192×293	0,7
	2. Module of analog-digital processing (MADP)	+	+		
CM4	1. Module of low-frequency marker (MLFM)	+	+	22,5×192×293	0,7

Variants of NLE integration

Based on the above description of structure the block of standardized apparatus, let us consider some variants of NLE integration, understanding under the latest hardware, operating the same time in the modes “Navigation” and “Landing”.

The results of the review are given in the table, where the sign “+” means “use” and the sign “–“ – “do not use” proper equipment in this mode.

Considering the fact that a typical element of the replacement is the CM, the composition of the equipment, operating in the mode landing from necessary for navigation mode one CM2, containing glide receiver with a synthesizer.

Since the secondary power supply module is combined constructively with the marker channel (in CM4), the last is included in the equipment of navigation, which can be used as a backup.

Obviously, with mass production, when one of the main requirements is to standardize equipment, more rationally use of the system of two building blocks. This increases the performance of the equipment by reducing the composition of necessary technological equipment and significantly increases system reliability both in the landing mode and in navigation mode. For the above reasons, the use of two complete sets CM1 ... CM4 is preferred in the case of the construction equipment on the basis of constructive “subrack”, i.e. in the general group case into whichthe various types of equipment CM are inserted.

Let’s consider the following variants of navigation and landing equipment for “small” airplanes:

a) a single set of operating in one mode: “Navigation” and “Landing”;

b) a single set for simultaneous work with the “Navigation” and “Landing”;

c) the double set of operating according to an embodiment “a”;

g) double set operating according to an embodiment of “b”.

Block diagram of NLE all four options is presented in Fig. 4.

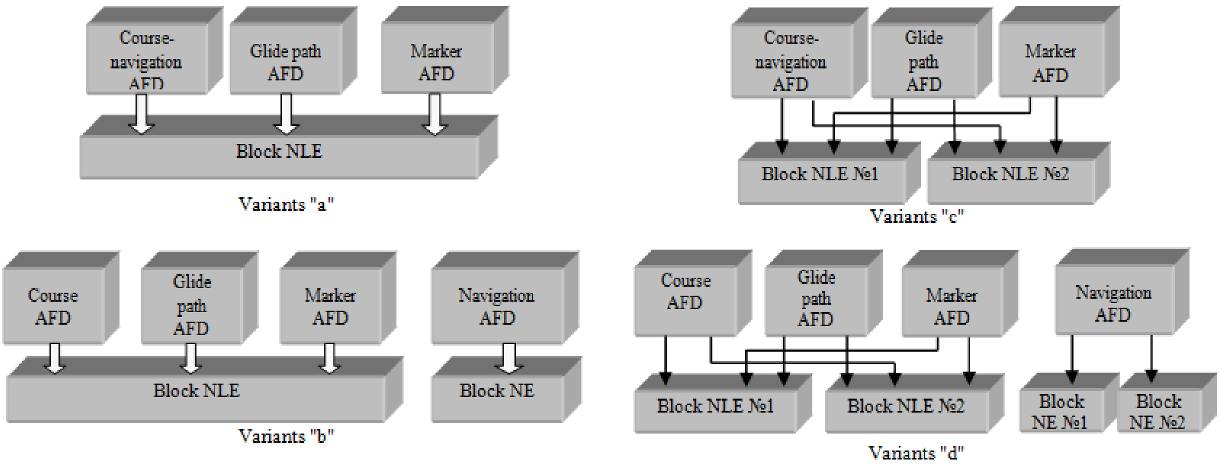

Fig. 4. Block diagram of NLE

Consideration of the above structure for this hardware shows that by the least weight and size characteristics (and cost) embodiment of “a” is the most preferred.

However, there are the followings limitations:

– inability to obtain simultaneously the navigation and landing data;

– the lack of reserve;

– the need for a combined course-navigation antenna-feeder devices (AFD).

When comparing with each other options “b” and “c” can be considered as the preferred second one by the reasons discussed above (unification), but the cost and weight of the equipment almost are doubled compared to option “a”.

The fourth option “d” is inferior to the first “a” on the weight and cost almost four times, but free from all failings of the first.

Conclusions

Thus, the final selection of complexing of the NLE is multi-alternative task. It should be solved for concrete type of object (aircraft, helicopter etc.) taking into account peculiarity of its usage, as well as the constructional and cost constraints.

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А. О. Осіпчук. Принципи створення уніфікованого базового комплексу навігаційно-посадкової апаратури
На підставі аналізу характеристик апаратури-аналога, вимог міжнародних технічних документів, з урахуванням експлуатаційної, економічної і технічної кон'юнктури показано принципи та шляхи побудови базового комплексу навігаційно-посадкової апаратури для "малої авіації" і можливості його технічної реалізації. Показано різні варіанти уніфікованних блоків навігаційно-посадкової апаратури залежно від їх призначення, проведено їх порівняльний аналіз.
Ключові слова: бортове навігаційно-посадочне обладнання; уніфікований блок; показники якості.

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А. А. Осипчук. Принципы создания унифицированного базового комплекса навигационно-посадочной аппаратуры
На основании анализа характеристик аппаратуры-аналога, требований международных технических документов, с учетом эксплуатационной, экономической и технической конъюнктуры показаны принципы и пути построения базового комплекса навигационно-посадочной аппаратуры для „малой авиации" и возможности его технической реализации. Показаны различные варианты унифицированных блоков навигационно-посадочной аппаратуры в зависимости от их назначения, проведен их сравнительный анализ.
Ключевые слова: бортовое навигационно-посадочное оборудование; унифицированный блок; показатели качества.

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